Amendments to the Drawings

The attached sheets of drawings include changes to Figs. 3-5. The sheets, which include Figs. 3-5, replace the originally filed sheets including Figs. 3-5.

Attachment: Replacement Sheets

Remarks

Applicant's counsel thanks the Examiner for the careful consideration given the application. The application has been amended to correct the cited informalities, to distinguish the claimed invention over the cited prior art of record, and to place the application as a whole, into *prima facie* condition for allowance. Substantial care has been taken to avoid the introduction of any new subject matter into the application as a result of the foregoing amendments.

Priority

We have submitted a certified copy of Canadian Patent Application No. 2349828 under a separate cover to comply with 35 USC 119 (b).

Drawings

The Examiner objected to the original drawings under 37 CFR 1.83 (a), concerning the elements 22, 24, 26, and 104 disclosed in the originally filed specification.

To overcome the Examiner's objection, reference numbers 22 and 104 have been deleted from the specification.

To overcome the Examiner's objection, reference number 24 has been added to Figs. 3-5 so that "24" refers to a schematic diagram for the secondary detector array. To overcome the Examiner's objection, reference number 26 has been added to Figs. 3-5 so that "26" refers to a schematic diagram for the opponent center/surround detector(s).

The amendments made to the application are fully supported by the application as originally filed. No new matter has been introduced by way of the amendments.

The Examiner has stated that "Any structural detail that is essential for a proper understanding of the disclosed invention should be shown in the drawings. ...".

Fig. 4 illustrates several primary detectors arranged in a concentric ring and central circle, connected to one secondary opponent center/surround, interleaved with other primary detectors from the same ring and circle connected to an opposite polarity center/surround, showing the manner in which a dual differential response may be derived from a spatial array of primary (inherently mono-polar) detectors.

Fig. 5 illustrates primary detectors providing input to three orientations of liner geometry opponent center/surround cells, all of which has the same polarity. These are summed by center and surround separately, resulting in a circular geometry center/surround of identical polarity.

It is believed that the original drawings show "secondary array 24" and "opponent center/surround detectors 26" as described in the specification.

The following FIG. A is one example of the secondary array applicable to the present application.

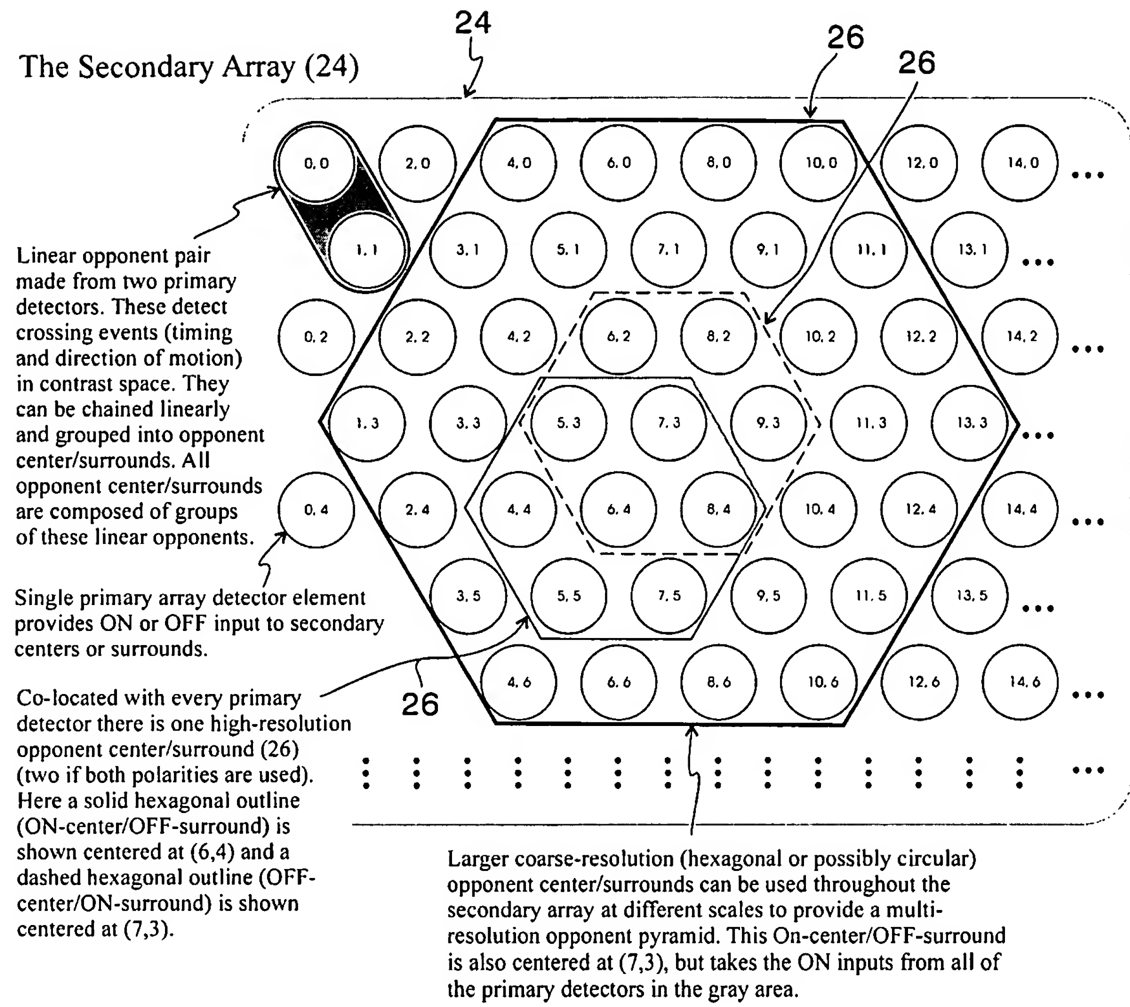


FIG. A

Referring to Fig. A, the secondary array is comprised of either a two-dimensional array of multiple ON-center/OFF-surrounds, or a two-dimensional array of multiple ON-center/OFF-surrounds and another two-dimensional array of multiple OFF-center/ON-surrounds representing the same scene area captured by the primary array. Whether one or two different polarity opponent center/surrounds are employed depends upon the application. Any single secondary opponent center/surround of either polarity (26) is part of the entire secondary detector array (24), however all ON-Center/OFF-surrounds are members of the ON-Center/OFF-surround sub-array, and similarly all

OFF-Center/ON-surrounds are members of the OFF-Center/ON-surround sub-array if there is one. Detector elements mimicking mammalian cones in the primary detector array are staring integrators, where "staring" refers to the fact that each individual "cone" detector is always detecting and sending its integration to the secondary layer. Primary detectors can feed secondary centers directly behind them (to OFF- and/or to ON-centers), and can feed ON- and/or OFF surrounds directly behind them for adjacent secondary centers. A secondary opponent ON-center/OFF-surround sums one or more primary central detectors feeding its center and subtracts the sum of the primary detectors feeding the corresponding secondary surround (typically from 3 or more primary layer detectors surrounding the primary center detector(s)). Polarities are simply reversed for OFF-center/ON-surrounds. For classical hexagonally packed primary detectors each secondary opponent center/surround has one primary detector feeding its center and six surrounding primary detectors feeding its surround, such that every primary detector feeds a secondary center and six secondary surrounds, leading to overlapping secondary detectors in the secondary array. The structure and function of Fig. A can be read by the originally filed application. Fig. A is one example of the secondary array, and another installation would be possible by reading the specification as a whole.

Applicant respectfully requests reconsideration and withdrawal of the objections.

Specification

The Examiner stated that the specification should be revised carefully in order to comply with 35 USC 112, first paragraph, concerning the oscillation means and the filter 20.

With respect to the filter 20, the specification at page 6, lines 17 to 24 has been amended for clarity. Support for the amendment can be found, for example, in the following originally filed description:

-- Spatially coincident opponent center/surround structures fed by the primary detector array are employed to remove spatio-temporally random detector-noise events. Spatially oscillating the image with respect to the detector, filtering only for those edges whose motions reflect purely the induced oscillation, and obtaining accurate phase information at edge-crossings accurately locates static edges. Spatio-temporal activity not suitably matching the space-time characteristics of the oscillation, or a Doppler shifted version of it, can be treated as noise. – (page 7, lines 21 to 28)

It is clear from this passage that the filtering <u>extracts</u> features whose motions reflect the induced oscillation, but treats other spatio-temporal activity as noise. According to original claim 1, the filtering removes noise. Thus, the spatio-temporal activity not matching the spatio-temporal characteristics of the oscillation or Doppler shifted version of it is removed, leaving the features extracted by the filtering.

The following paragraph also provides support for the removal of noise other than detector noise, and support for the expression "spatio-temporal motion signature of the induced oscillation".

--By intermittently adding a one-dimensional or a two-dimensional pre- determined spatial oscillation to the image or the detector array, real edge crossing events due to static edges in the image crossing these detectors (solely due to the relative oscillation) will possess the spatio-temporal motion signature of the induced oscillation. These events can be filtered for, since the oscillation path is known or can be accurately tracked. – (page 17, lines 19 to 24)

According to page 6, line 17 to page 7, line 6, it is clear that in one embodiment, the system includes a primary detector array 12, means 18 for inducing a spatial oscillation and a filter 20, and further includes a secondary array 24 of opponent center/surround

detectors. Thus, in the embodiment, the filter 20 is a component separate from the detector arrays 12 and 24.

With respect to the oscillation means, it is clear for one of ordinary skill in the art that the action of oscillation serves to move the image of the viewed scene upon the primary detector array, by reading the specification as a whole. The primary array truly "stares" (i.e., there are no frames captured).

In addition to the above cited passages, the originally filed specification provides, among others, the following paragraphs:

-- the induced oscillation means is provided by a swept-frequency sinusoid chirp...-- (page 6, lines 25 to 21)

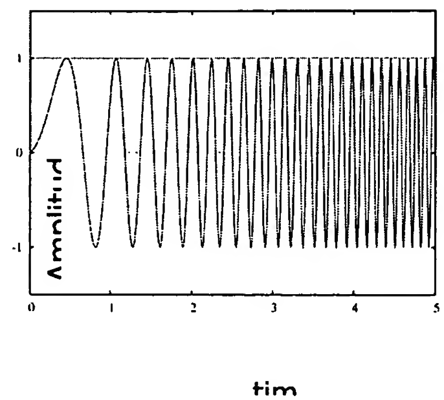
-- means 18 for inducing a spatial oscillation in the image 16 relative to the primary detector array 12...-- (page 6, lines 20 to 21)

-- In an embodiment of the present invention, the spatial oscillation step is provided by a swept-frequency sinusoid chirp...-- (page 7, lines 12 to 13)

-- In an embodiment of the present invention, a chirp in one or more dimensions can be put to particular use as the induced oscillation...-- (page 8, lines 27 to 29)

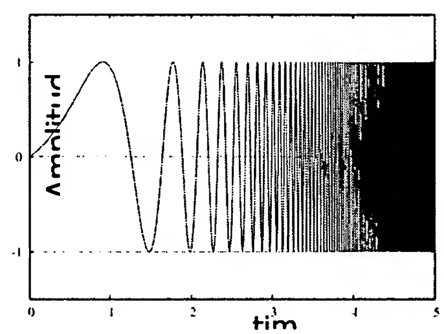
The chirp (method) is well known in the art. (e.g., http://en.wikipedia.org/wiki/Chirp, http://en.wikipedia.org/wiki/Pulse_compression). One of ordinary skill in the art would understand how to induce a spatial oscillation in a signal, by the chirp method.

The following Figs. B-C shows example of a linear-swept-frequency sinusoidal chirp.



The classical linear chirp function linearly increases frequency with time, and is a constant-amplitude

FIG. B



The exponential chirp function increases frequency exponentially with time, and is also a constant-amplitude sinusoid.

FIG. C

Fig. B shows a time-linear sweep. Fig. C shows a time-exponential sweep. Both of the sweeps are prior art and are examples of the spatial oscillations employable in this application.

Thus, one of ordinary skill in the art would understand by reading the specification as a whole that in one embodiment, the means for inducing a spatial oscillation in the image is provided by the chirp method, through which a spatio-temporal signature is created.

Accordingly, it is believed that the means for inducing a spatial oscillation is clear and concise. Applicant respectfully requests reconsideration and withdrawal of the objections.

Claims

Independent claim 1 has been amended for clarity. Claim 1 recites "a primary detector array ...", "means for inducing a spatial oscillation ...", "a secondary array of opponent center/surround detectors ...", "means for calibrating ...", and "a filter spatio-temporally matching the oscillation, for filtering ...".

Support for "a primary detector array ..." can be found, for example, on page 6, lines 17 to 24 and original claim 3 of the originally filed specification.

Support for "means for inducing a spatial oscillation ..." can be found, for example, on page 7, lines 21 to 28, page 17, lines 19 to 24 and claim 16 of the originally filed specification.

Support for "a secondary array of opponent center/surround detectors ..." can be found, for example, on page 4, line 5 to 13 and original claim 3 of the originally filed specification.

Support for "means for calibrating ..." can be found, for example, on page 11, lines 11 to 23 page 14, lines 13 to 22 and original claims 1, 3 and 10 of the originally filed specification.

Support for "a filter..." can be found, for example, on page 7, lines 7 to 11 and 21 to 29, page 17, lines 19 to 24, and page 18, lines 19 and 20 of the originally filed specification. According to these passages, the filter is a spatio-temporal filter for auto-correlating real objects in the scene modulated by the specific applied oscillations; the filtering extracts features whose motions reflect the induced oscillation, but treats other spatio-temporal activity as noise since noise cannot correlate with the matched filter and is removed.

Claim 2 has been amended for clarity.

Claims 3 and 4 have been cancelled without prejudice or disclaimer.

Claim 5 has been amended to bring it into conformity with the amended claim 1.

Claim 6 has been amended to bring it into conformity with the amended claim 1.

Claim 7 has been amended to bring it into conformity with the amended claim 1.

Claim 8 has been amended to bring it into conformity with the amended claim 1 and for clarity. Support for the amendment made to claim 8 can be found, for example, on page 11, lines 6 to 10.

Claim 9 has been amended for clarity. Support for the amendment made to claim 9 can be found, for example, on page 15, lines 12 to 29 of the originally filed specification.

Claim 10 has been amended to bring it into conformity with the amended claim 1.

Claim 11 has been amended for clarity. Support for the amendment made to claim 11 can be found, for example, on page 15, lines 1 to 9 of the originally filed specification.

Claims 12 and 13 have been amended for clarity.

Claims 14 and 15 have been amended to bring them into conformity with the amended claim 1.

Independent claim 16 has been amended to add changes corresponding to those of claim 1.

Claim 17 has been amended to correspond to claim 2.

Claim 18 has been amended for clarity.

Claims 19 has been cancelled without prejudice or disclaimer.

Claims 20 to 26 have been amended to correspond to claims 6 to 12, respectively.

Claim 27 has been amended to bring it into conformity with claim 16.

New dependent claims 28 to 37 have been added. Support for new claims 28, 29, 31, and 32 can be found, for example, in Fig. 6 and its corresponding description (e.g., page 13, lines 3 to 16) of the originally filed application. Support for new claims 30 and 33 can be found, for example, on page 4, lines 5 to 13, page 6, line 25 to page 7, line 6, of the originally filed specification. Support for new claims 34 and 35 can be found, for example, on page 14, lines 13 to 22 of the originally filed specification. Support for new claims 36 and 37 can be found, for example, on page 6, line 25 to page 7, line 6 of the originally filed specification.

The amendments made to the claims are fully supported by the application as originally filed. No new matter has been introduced by the amendments made to the claims.

Claim Rejections-35 USC §102 and §103

The Examiner rejected claims 1 and 16 under 35 U.S.C. 102(b) as being anticipated by "Aliasing reduction in staring infrared imagers utilizing subpixel techniques by Joseph C. Gillette et al. (hereinafter referred to as Gillette). The Examiner rejected claims 3-5, 18 and 19 under 35 U.S.C. 103(a) as being unpatentable over Gillette in view of Spitzer (US Patent 6,912, 307).

As discussed, the claims have been amended to more clearly define the invention. Applicant respectfully requests reconsideration and withdrawal of the rejections for reasons as set out below.

The present application discloses a system having a primary detector array, means for inducing a spatial oscillation, a secondary detector array and a spatio-temporally matching filter. The filter removes noise events to thereby provide enhanced signal processing. To do so, first the image is spatially oscillated with respect to the detector. Static edges are then located by filtering for those edges whose motions reflect purely the induced oscillation. Spatial-temporal activity not suitably matching the space-time characteristics of the oscillation, or Doppler-shifted version of it, is as treated as noise, and thereby removed from signal processing (US Patent App. Publication 2004/0135898, pg, 3, c.1, s. [0036] to [0039]).

The system of the present application applies a spatio-temporal oscillation incorporating velocities, frequencies, and motions traversing paths, which is what the matched filter is matching (US Patent App. Publication 2004/0135898, pg, 3, c.1, s. [0042]) – not blocks of static pixels in frames.

In the Office Action (page 4), the Examiner has stated that Gillette discloses ". . . a spatio-temporally matching filter in communication with the image detector and the oscillation means for providing enhanced image processing of the image, the matching

filter being configured to filter out aspects of the image signal not associated with the induced oscillation (Block Matching, section 3.2.1) . . ." .

The purpose of Gillette's Block Matching Algorithm is to estimate the sub-pixel-accurate displacement of blocks of pixels between frames to facilitate registration of multiple frames on a finer spatial grid (Gillette, pg. 3134, c. 2, pg. 3135, c. 1). It must be noted that any real motions of objects in the scene between frames will corrupt the global motion estimate of a given frame (Gillette, pg. 3133, c. 1, ln. 16 -19). Gillette's process is incapable of calibrating individual pixels, let alone doing so in real-time, or avoiding saturation of bright areas. In his array, detector noise is permanently integrated with both pixel mis-calibration and with real image data separately at every pixel due to lack of intra-frame event tracking, unlike the present invention. Once the finer registration of multiple frames has been estimated by Gillette, averaging and interpolation are applied which reduces noise somewhat, but also smoothes out real details. Calibration is not accomplished.

Gillette does not suggest a spatio-temporally matching filter that uses a spatio-temporal motion signature of the induced oscillation.

The present invention's ability to perform pixel-specific calibration of zero-offsets, and gamma differences, and perform noise de-correlation in real-time, relies on matched filtering, and continuous event tracking at the secondary detector array. This enables increased spatial- and luminance-resolution, and low-light and low-contrast detection, which would otherwise be masked by mis-calibrated noise-polluted integrating pixels.

It is believed that Gillette is completely different from the present invention. A detailed comparison of the present application and Gillette's aliasing reduction article follows, with further specific differences discussed below.

As described in the present application, each primary array pixel is individually continuously staring. The applied oscillation is a spatially and temporally continuous function modulating the real motions of objects in the scene upon the detector array. The applied oscillation is matched in real-time by a filter in the image detection path, after the secondary detector array.

The image processing of claims 1 and 16 is not frame-based, and derives information directly from scene motions across pixel boundaries during continuous real-time exposure.

The opponent center/surround secondary detector layer continuously receives input from the primary array of pixels. Any luminance edge (or any other detectable field edge such as infrared, x-ray, pressure, etc.) crossing between primary detector pixels will instantly create a pulse at the corresponding location in the secondary detector layer, giving a spatially localized time stamp of that event. Every spatial real motion of any object edge (and any temporal luminance-change in the field of view), modulated by the induced oscillation, will create an oscillating path of pixel-crossing pulses, therefore every modulated motion event (or luminance-change event) will create a spatial and temporal event datum, such that no scene event or timing is lost, permitting luminance changes to be easily distinguished from motions of luminance edges. An edge oscillating over a set of pixels will create secondary detector layer event pulses in real-time at each pixel edge being crossed, for every crossing occurrence. Spatially this will leave a trail of pulses following the object edge, and the pixel locations and times of crossing may be processed by a spatio-temporal filter matching the induced oscillation in real-time. This will give a high autocorrelation value for scene objects modulated by the applied oscillation. Pure luminance changes without real motions will register as temporal contrast changes, modulated only by the applied spatial oscillation. Detector noise events will be highly unlikely to mimic the oscillation in both space and time, and would thus be filtered out. Alternatively, if temporal filtering is done discretely at each

pixel location in the secondary detector array, the sequence of pulses at any single location under the oscillating object edge will autocorrelate with the applied oscillation. This process is performed by the continuous, dense spatio-temporal sampling of all object events at the detector enabled by the opponent center/surround analysis of the staring primary array. The present invention is not a frame-based video system, and not in luminance space (US Patent App. Publication 2004/0135898, pg. 3, c. 1, s. [0042] to [0044]).

By contrast Gillette et al, in Article 'U' describe a method of "uncontrolled micro-scanning" for reducing aliased signal energy in a sequence of temporal image frames obtained by periodically sampling an image with a finite array of image detectors. In micro-scanning, the subpixel shifts between the temporal image frames are either random and, therefore, must be predicted to facilitate image reconstruction, or controlled and periodic, such that a super-resolved image may be generated by interpolating multiple frames on the higher-resolution grid. Controlled micro-scanning actually involves shifting of the detector occurring only between the captured image frames. These classical image frames are integrated during exposure so that any motion during frame exposure (as in uncontrolled micro-scanning) would cause blur, and the exact time and path of any motion occurring during the frame exposure would be lost. Between frames all scene information is lost since Gillette's detector array is not imaging then by definition, and there is no method described for recording all scene events spatio-temporally, leaving a seriously incomplete scene-event history to match any filter against (Gillette, pg. 3133 to 3134, s. 3.1 to 3.2).

Due to the nature of uncontrolled micro-scanning, and the spatio-temporally incomplete motion data captured, Gillette's method cannot use specific controlled oscillations and matched filters (optimized for signal processing applications), to determine and compensate real-time pixel noise at each pixel, or real-time individual pixel calibration. Even using controlled oscillation (where Gillette would not want motion during frame-

capture), insufficient spatio-temporal data caused by frame-based imaging prevents advantageous use of specific oscillations (e.g., for signature analysis or real-time intra-frame object velocity determination) (Gillette, pg. 3133, c. 2, ln. 9 – 11).

According to the present invention, the method and system uses the continuous-time spatio-temporal data, selected oscillations and matched filtering to capture true motion, determine instantaneous object velocities, calibrate and de-noise pixels in real-time, determine object velocities, increase useful dynamic range for the detector, and super-resolve the image based upon time-resolved edge crossings (since objects transitioning between pixels can have precise spatial and timing information not available on an integrating frame-based detector) (US Patent App. Publication 2004/0135898, pg. 3, c. 1, s. [0042], [0043], [0050], [0059]).

The Block Matching process disclosed by Gillette makes use of a motion estimation technique, and a high-resolution reconstruction technique. The motion estimation technique estimates the subpixel shifts that occur between successive temporal image frames by comparing the gray-scale values of successive image frames, on a block-by-block basis. Initially, an MxN pixel block template is selected from one of the temporal image frames. Then, the next image frame is scanned over an (M+2P) x (N + 2P) search area, where P is the maximum whole pixel shift. A mean absolute error (MAE) is then calculated between the pixel block template and each MxN pixel block in the search area. The MxN pixel block in the search area that yields the minimum MAE provides an estimate of the nearest whole pixel shift. Spatial interpolation between the pixel block template and the minimum-MAE block is then used to provide an estimate of the next subpixel shift. Accurate Block Matching relies upon there being no motion in the scene other than shifts between frames during the entire acquisition process. Gillette's high resolution reconstruction technique maps each frame in the image sequence onto a high resolution grid, based on the respective estimated interframe displacement. If the estimated shift is the same for multiple frames, then the pixel

values at the overlapping positions are averaged to suppress noise. Finally, the pixel values for regions of the high-resolution grid lacking any image frame are calculated using a nearest-neighbor interpolation algorithm (Gillette, pg. 3134 to 3135, s. 3.2.1, 3.2.2).

Gillette also compares the foregoing uncontrolled micro-scanning method against a controlled micro-scanning method. In the controlled micro-scanning method, the subpixel shifts between the temporal image frames are controlled and, therefore, are known a priori. The method involves scanning L^2 frames, with the subpixel shift of each frame being an integer multiple of 1/L. The shifted images are interlaced horizontally and vertically onto a uniform grid to form a high-resolution microscanned image, without any further image processing. On page 3134 Gillette discloses that the effect of noise events on image signal quality can be reduced by increasing the depth L of the micro-scan, and increasing the sampling frequency (e.g., increased spatial resolution detector – which is what he is trying to avoid in the first place, or increased number of captured unique frames – leading to longer delay increasing the probability that intra- and inter-frame motions will degrade the motion and super-resolution estimates).

Applicant also wishes to point out that Gillette must estimate the subpixel shift in each frame for several frames, resulting in multiple frame delay for one high-resolution image. Also, the frame basis of Gillette's method, and the corresponding finite exposure times, result in motion blur or aliasing (the interlaced motion shear effect in television freeze-frames) as objects in real motion traverse the scene.

In contrast, since the filtering of independent claims 1 and 16 is carried out with knowledge of the induced spatial oscillations, the present invention allows object crossings over the image detector to be identified in real-time effectively super-

resolving edges by their crossing times at the focal plane, without the multiple-frame delay (or any delay) required by Gillette.

As will be apparent from the foregoing discussion, Gillette does not teach the subject matter defined by amended claims 1 and 16.

Spitzer does not add any teaching to Gillette to render claims 1 and 16 unpatentable.

With respect to the rejection to claim 3, the Examiner has stated that while Gillette discloses the limitations of claim 1, he fails to do so for claim 3, however it would have been obvious to combine Spitzer's staring opponent center/surround vision system with Gillette's oscillation and matched-filter processes.

Regarding Spitzer et al and claim 3, since Carver Mead first modeled human vision in silicon in the mid 1970s, there have been many implementations to mimic the processing of the retinal neural structures as they are understood. The global assumption made in vision theory about micro-saccades (the intermittent bursts of eye oscillations over a half-cone-diameter to several cone-diameters in amplitude, which occur several times per second in the 50 to 200 Hz range), has been that they serve to refresh the image upon the retina, since without motions the decay time-constant of the cones causes the scene to fade (Hubel). Thus, in the absence of any other information, Spitzer's (or Carver Mead's) array need only be oscillated to satisfy this function. <u>No filter is required for the scene-refresh application.</u>

It is presumed that the retinal neural structure is capable of tracking millions of edge crossing events discretely in real-time over the retina to consider the possibility that a) the oscillation is not purely random or purely to refresh the fading scene, and that b) there needs to be a spatio-temporal tracking filter, phase-locked to the induced oscillation, that only passes events matching the applied oscillation – or a Doppler-shifted version of it. This is a very controversial claim made in this application, and

Spitzer does not suggest filtering induced oscillations. Spitzer applies his retinal circuits purely to perform essentially static color correction (i.e., correcting scene color shifts due to variations in ambient lighting), and shows no means of calibrating or de-noising individual pixels in substantially-faster-than-frame-rate real-time.

As discussed, Gillette fails to disclose or suggest the subject matter defined by claims 1 and 16. Spitzer cannot add any teaching to Gillette to render claims 1 and 16 unpatentable.

In view of the foregoing, Applicant respectfully submits that all of the Examiner's substantive bases for rejection of claims 1 and 16 should be deemed overcome. Therefore, reconsideration and withdrawal of the rejection of claims 1 and 16, and allowance thereof are respectfully solicited.

In view of the above amendments, remarks and having dealt with all of the objections raised by the Examiner reconsideration and allowance of the application is courteously requested.

Inasmuch as dependent claims 2, 5 - 12, 14, 15, 17, 18, 20 - 26 merely serve to further define the subject matter of amended independent claims 1 and 16, which themselves should now be deemed allowable, reconsideration and withdrawal of the rejections of claims 2, 5 - 12, 14, 15, 17, 18, 20 - 26, and allowance thereof, are respectfully solicited.

Inasmuch as new dependent claims 28 - 37 merely serve to further define the subject matter of amended independent claims 1 and 16, which themselves should now be

deemed allowable, consideration and allowance of those claims are respectfully solicited.

Applicant respectfully submits that in view of the foregoing amendments, the application as a whole is now in prima facie condition for allowance; reconsideration and allowance of the application as a whole are respectfully solicited.

The present Amendment and Communication adds ten (10) new claims while cancelling five (5) for a net gain of five (5) total claims. Applicant hereby authorizes that the small entity extra claim fee of $125.00 for five (5) extra total claims be charged to Applicant's attorney's deposit account number 502428.

Should anything further be required, a telephone call to the undersigned at (312) 456-8400 is respectfully requested.

Respectfully submitted,

GREENBERG TRAURIG, LLP

Dated: September 3, 2008

Douglas B. Teaney
One of Attorneys for Applicant

CERTIFICATE OF MAILING

I hereby certify that this AMENDMENT AND RESPONSE TO OFFICE ACTION is being deposited with the United States Postal Service as first class mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on September 3, 2008.

57,471,596